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EVALUATION OF "AQUAROBIC" SEWAGE TREATMENT SYSTEM

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Ministry of the Environment

Ontario

The Honourable
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Minister

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Deputy Minister

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EVALUATION OF "AQUAROBIC" SEWAGE TREATMENT SYSTEM

By

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ABSTRACT

The Aquarobic sewage disposal system developed by Waltec Industries Ltd., of Wallaceburg was evaluated for continuous performance over a 12 month period at the Ontario Research Foundation. The system, essentially consisting of an aeration tank, aeration equipment, a settling tank and a gravity sand filter, was tested at two sewage loading rates of 212 and 333 Imp. gallons per day.

The values for BOD_5 and suspended solids in 85% of the samples of the effluent from the settling tank were equal to or less than 25.6 mg/l and 41.2 mg/l at the sewage loading rate of 212 Imp. gal. per day and 49.9 mg/l and 92.9 mg/l at 333 Imp. gal. per day respectively. The corresponding values in the filter bed effluent for BOD_5 and suspended solids were 5.2 mg/l and 9.5 mg/l at the lower rate and 5.2 and 11.0 mg/l at the higher test loading rate.

An organic and hydraulic shock load upset operation in the mechanical part of the system for 2-3 hours. The sand filter however, absorbed the shock to a great extent. The BOD_5 and suspended solids in the effluent from the settling chamber at one stage were 89 mg/l and 174 mg/l respectively. The suspended solids in the filter bed effluent also were increased 36.8 mg/l.

The air supply arrangement for the system required frequent maintenance.

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PROJECT STAFF

The following staff of the Ministry were instrumental in the production of this report.

R.R. Cheng

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1.0 INTRODUCTION

A number of sewage "package treatment plants" have been on the market for a long time for use in areas where conventional septic tank systems could not be installed. Some of these have been allowed by the regulatory agencies in Ontario for individual houses, motels, service stations, apartments, etc. Unfortunately, most of them failed to produce satisfactory results due to poor design, lack of maintenance and servicing, or availability of spare parts.

Waltec Industries, Wallaceburg, Ontario, have developed a sewage treatment system for individual homes and installed six experimental units which were under their observation, and apparently in the process of modification, for the past 3 to 4 years. On the basis of promising results of their operations, they offered the Aquarobic treatment system for evaluation by the Ministry.

The system was installed by Waltec on the property of the Ontario Research Foundation (ORF), Sheridan Park. Arrangements were concluded between Waltec and ORF for testing in accordance with Ministry criteria. The system was buried underground with an access from the top for observation and sampling, etc. A small shed was used for housing the air compressor and allied electrical components. The sampling equipment was also protected from weather by a structure.

The system was put into operation and testing began on September 5, 1972 and concluded on September 4, 1973.

2.0 PLANT DETAILS

The "Aquarobic" is an extended aeration system designed to treat the waste from individual homes. The system essentially consists of an aeration chamber with a baffle, a settling tank, with related air lift pumps, electrical and mechanical equipment and a sand filter. The system is shown schematically in Fig. 1. Details are given in Fig.2.

2.1 Aeration Tank

Raw sewage enters the first part of the aeration chamber which contains a minimum of 250 Imp. gal. of mixed liquor. Here the raw sewage is mixed with activated sludge from previous treatment and oxygen from air supplied by an air blower through air diffusers.

The mixed sewage then flows by gravity through three holes and a slot in the centre baffle plate into the second part of the aeration chamber which is provided with an air diffuser similar to that in the first part of the chamber. The aeration process is continuous.

A small amount of the air fed to the diffuser header is bled off via an orifice to operate the output control lift pump for transferring the liquid from aeration to settling chamber. This air lift pump is designed to lift water a fixed height and to operate continuously and automatically. When there is no flow into the system, the aeration tank freeboard capacity is approximately 100 Imp. gal. As raw sewage enters the first aeration chamber, the liquid level in the second aeration

chamber rises and the output air lift pump starts to operate and continues to operate until the freeboard capacity is again about 100 Imp. gal. An instantaneous input of 50 Imp. gal. would be necessary before the air lift pump would have a peak output to the settling tank of more than 3 gpm. As the liquid level in the aeration tanks decreases so does the lift pump output.

2.2 Settling Tanks

The settling tank capacity is 90 Imp. gal. It is fitted with a surge plate to buffer incoming flow, a retention baffle for floating sludge, five inclined plate acceleration baffles, and a saw-toothed overflow weir. There are two pipes connecting the aeration chamber to the settling tank. At peak flows of 3 gpm, the minimum settling time would be 30 minutes. In actual household use, the settling times could be much longer due to use patterns and the decreasing output of the control lift pump with head reduction in the aeration chambers. The second pipe leads to the first part of the aeration chamber from an air lift sludge return pump installed in the leg of the settling tank. On a periodic basis, the total blower air supply is directed from the air diffusers to the air lift sludge return pump by the action of a motorized valve acting on a timer signal. This lift pump returns 60 gal. from the settling tank to the first aeration chamber. The action simultaneously washes the settling tank walls and baffling plates, returns settled sludge, and breaks up floating sludge. The pumpback requires 5 minutes and is normally done every 12 hours.

2.3 Sand Filter

The settling tank effluent passes into a sand filter 120 ft^2 in area (12 ft x 10 ft) and 30 inches deep. (Fig. 3)

A medium sand with a uniformity coefficient C_u of about 5 and effective size (D_{10}) of approximately 0.26 mm is used. The effluent is distributed through 3 plastic, perforated pipes, each 10 feet long, and through 4 cross members (totalling 14 feet in length) on top of the filter sand. At the bottom are two 10-foot long perforated collector pipes connected to a header which returned the final effluent to a sump for pumping it to a sampling tank, and then to the sewer line. The pipes are 4" I.D. and the two rows of holes, at the 4 o'clock and 8 o'clock positions are of 7/16" diameter, spaced 5" apart along the length of the pipe.

2.4 Construction & Mechanical Components

The tank construction is of fibreglass reinforced polyester resin, chemically inert to most household chemicals and to soils. There are no moving components in the tanks and all internal components are PVC or ABS plastic.

The air blower is of the Roots type and normally operates at 1140 r.p.m. A 1/3 H.P. motor is used to drive the blower and draws 3.2 amps at 120 volts AC. Power consumption of the mechanical system is 0.25 KVA.

The mechanical components are protected by a noise-insulated fibreglass housing. Noise level of the operating unit

has been reported as 54 dBA at a distance of 3 feet from the housing and 48 dBA at 15 feet with surrounding noise level at 47 dBA.

2.5 Equipment Specifications & Data

1. General

Number of persons serviced	up to 8 according to Waltec
Daily design flows - Imp. gal.	up to 400
BOD_5 capacity - pounds per day	up to 1.36
Aeration tank capacity - Imp. gal.	600
Settling tank capacity - Imp. gal.	90
Blower capacity, $ft.^3$ per minute	6.5

2. Aeration Tank

Capacity of tank = 600 Imp. gal.

$$= \frac{600}{6.24} = 95 \text{ ft.}^3$$

M.L.S.S. in tank = 640 rising to 3,999 mg/1 on 365th day (O.R.F. reports)

Retention time in tank = $\frac{600 \times 24}{400}$ = 36 hours at maximum design flow.

3. BOD Loading Rate

BOD loading per person = 0.17 lb per capita

for six persons = 0.17 x 6 = 1.02 lb. per day

loading rate = $\frac{1.02}{95}$ = 0.01 lb. BOD/ft^3 of aeration tank per day.

4. Air Requirement

The air blower is rated at 6.5 $ft.^3/min.$

Air supply to lift pump for aeration tank outlet control.

= 1 to 1.5 $ft.^3/min.$

Air supply for aeration

= 5 $ft.^3/min.$

= 7,200 $ft.^3/day.$

On the basis of 80% removal of 300 mg/l BOD_5 from 400 gal/day sewage, 7200 ft^3 air/day provides

600 lb air/lb BOD removal

which at 5% oxygen transfer efficiency is equal to

6 lbs O_2/lb BOD removed

5. Settling Chamber

Settling chamber area = 2.5 x 3 ft.

Effective surface area = 7.5 x 2/3 = 5 $ft.^2$

Surface overflow rate = $\frac{400}{5}$

= 80 $g/ft.^2/day.$

Settling chamber retention = $\frac{900 \times 24}{400}$

= 5.4 hours at max. design flow.

6. Sludge Return

Sludge return every 12 hours from settling tank to the first aeration compartment; pumping time 3.5 - 5 minutes.

3.0 SEWAGE SOURCE AT TEST FACILITY

The sewage used in the testing program was taken from a subdivision of the Town of Mississauga to the northwest of the O.R.F. test facility.

3.1 Diversion of Sewage to Test Facility

The sewage is diverted from a manhole in a 12" diameter gravity sewer through a 10" diameter line to a manhole and from there, through a 6" diameter sewer to a manhole on the O.R.F. property. From this manhole, the sewage is pumped through a 2" diameter plastic forcemain to the test facility (See Fig. 4).

The effluent from the facility flows into a 10" diameter gravity sewer and from there into a 12" diameter sewer, in the town sewage system.

3.2 Sewage Flow Within the Test Facility

The sewage comes into the facility through a 2" diameter plastic forcemain. Within the facility, the flow is split by a "Y" connection into two 2" diameter pipes, Line 1 and Line 2 (Fig. 5). Line 2 is used only as a standby.

Line 1 runs the length of the building, and at the end of the building, makes a "U" turn. It is at this point that sewage was drawn off through a 1½" diameter vertical plastic pipe, reducing to a 1" diameter plastic pipe running into a pump. The sewage was pumped through a 1" diameter plastic pipe to the Waltec Aquarobic Unit.

Line 1 continues to a plastic tank where it empties. Line 2 runs directly to the plastic tank where it empties.

4.0 SAMPLING

The influent sewage was sampled at a point just ahead of the suction port of the feed pump, by a small peristaltic pump programmed to sample continuously during the periods the feed pump was operating. The sample was refrigerated and the 24 hour composite sample was analysed.

Beginning August 1, 1973, however, the sampling procedure was modified. The raw sewage input line to the Aquarobic was led to a 45 gallon drum fitted with a propeller mixer which was operated continuously. Grab samples were collected 2-3 times a day.

The effluent from the system was analysed at two points:

(i) at the output of the settling tank (OUT 1)

(ii) at the output of the sand filter (OUT 2)

The sample from the settling tank was withdrawn from a small well in the horizontal effluent pipe by a diaphragm pump, programmed to the feed pump, but lagging it by about 30 minutes.

The effluent from the sand filter emptied into a sump tank and periodically, determined by the liquid level, was pumped to the main sewer by a sump pump. At a point in this return line just ahead of the junction with the sewer a "Y" was inserted, one leg of which led to a 50 gal. tank. Thus, whenever the sump pump was activated a portion of the effluent was diverted to this collecting tank.

Each day the tank was stirred and a sample taken for analysis. The tank was then drained, ready for the next collection.

During discontinuous feeding tests, before each dump was made, the 45 gallons of raw sewage in the influent drum was stirred and a sample of raw sewage withdrawn.

5.0 LABORATORY ANALYSES

Daily 24 hour composite samples were collected for the (a) raw sewage, (b) effluent from the settling chamber (OUT 1) and (c) final effluent from sand filter (OUT 2).

The samples were tested for:

(1) BOD_5' suspended solids, volatile suspended solids, nitrate and total phosphorus every day from September 5, 1972 to September 4, 1973.

(2) Total and soluble organic carbon every day from September 5, 1972 to February 5, 1973.

(3) Nitrogen as free ammonia, Total Kjeldahl and nitrite, total and faecal coliforms once a week from September 5, 1972 to September 4, 1973.

The number of samples tested and range of values for each parameter are shown in Tables 1 and 2.

6.0 SEWAGE LOADING RATE

The BOD_5 value for waste water from individual homes is assumed to be 0.1 to 0.15 lb. per capita per day.

The analysis of raw sewage over a three month period at Sheridan Park shows an average value for BOD_5 to be 190 mg/l or 190×10^{-5} lb/gal. Considering a family of 4 persons and 0.1 lb. per capita per day of BOD_5:-

$$\frac{\#BOD/day}{\#BOD/gal} = gal/day.$$

Daily BOD_5 loading = 0.1 x 4 = 0.4 lb.

$$\text{Volume of sewage required for testing} = \frac{0.4 \times 10^5}{190}$$

$$= 210 \text{ Imp. gal./day.}$$

Assuming 0.15 lb. BOD_5 per capita per day:-

$$\text{Volume of sewage required for testing} = \frac{0.60 \times 10^5}{190}$$

$$= 315 \text{ Imp. gal./day}$$

The system was tested at two loading rates of 212 and 333 Imp. gal./day.

7.0 SEWAGE LOADING PATTERN

The rates of flow of raw sewage are shown below. The system was hydraulically loaded according to the flow pattern as shown. Such a procedure was intended for hydraulic or organic equalization and is similar to that described in Standard 40 by the National Sanitation Foundation, Ann Arbor, Michigan.

7.1 212 Imp. gal/day 5th September, 1972 - 10th June, 1973

0730 hours to 0900 hours	35% of total daily flow =	75 gal.
1145 hours to 1315 hours	18% of total daily flow =	37 gal.
1800 hours to 2000 hours	47% of total daily flow =	100 gal.
	Total	212 gal.

7.2 333 Imp. gal/day (11th January, 1973 to 4th September, 1973)

0630 hours to 0900 hours	37% of total daily flow =	123 gal.
1100 hours to 1315 hours	23% of total daily flow =	74 gal.
1730 hours to 2000 hours	40% of total daily flow =	136 gal.
	Total	333 gal.

In addition, discontinuous feeding tests were carried out by dumping 45 Imp. gallons of sewage according to the schedule shown in Table 3 from July 17, 1973 to July 26, 1973 and again from August 14, 1973 to August 18, 1973.

8.0 SHOCK LOADING

One of the aspects to be considered is the effect of dumping large volumes of waste from a bathtub, a dishwashing or a laundry machine on the operation of the system.

The system had been in operation at sewage flow of 212 Imp.gal/day commencing September 4, 1972, and the conditions were considered to have stabilized when the first shock load was applied at 1000 hours on December 14, 1972. This consisted of 37 Imp. gal of raw sewage (BOD_5 117 mg/l and S.S. 67 mg/l) which was dumped into the aeration chamber in 7 minutes and 45 seconds. The values of BOD_5 and suspended solids measured in the effluent from settling chamber OUT 1 are given in Table 4.

The highest value for BOD_5 was 34 mg/l in the sample collected ½ hour after the shock load was applied.

Most of the values were between 15 mg/l and 23 mg/l during five hours of sampling at 30 minute intervals. Similar values for BOD_5 were found 23 hours and 28 hours after the application of the shock load.

The values for suspended solids during the 5 hour intensive sampling period were in the range of 18 - 39.6 mg/l. The highest value, 39.6 mg/l, occurred 30 minutes after loading, the same time at which the BOD was highest. After 23 hours and 28 hours the suspended solids were 42.8 mg/l and 39.2 mg/l, respectively.

From these observations, it appears that there were no abnormal values that could be considered of much

significance as the result of this shock load.

Another shock was administered at 0845 hours on January 9, 1973. It consisted of 37 Imp. gallons of tap water and 2/3 cup of household detergent (Tide). This was dumped into the aeration chamber in 7 minutes and 45 seconds, approximately midway on a feeding period of 2½ hours during which 120 gallons of sewage were pumped to the Unit.

The BOD_5 in the sample of the effluent (Table 5) from the settling chamber (OUT 1), 30 minutes after the shock load, increased from 18.6 to 36.2 mg/l and to greater than 82.5 mg/l after 60 minutes. The corresponding values for suspended solids in the two samples were 87.0 and 495.0 mg/l respectively.

The BOD_5 and suspended solids in the sample taken after 1½ hours, were 128 and 62.5 mg/l, respectively. The values became normal after approximately two hours.

From January 12, 1973, the system was in operation at the sewage loading of 333 gal/day.

Another shock load similar to that on January 9, 1973 was applied on February 20, 1973 at 0815 hours. The load consisted of 37 gallons tap water and 2/3 cup of household detergent (Tide), and was added during a time interval of 5 minutes. Raw sewage was also being fed into the reactor at this time at the rate of 0.82 Imp. gal./minute for a period of 2½ hours.

The samples were collected from the effluent discharging from the settling chamber (OUT 1) as well as from

the sand filter (OUT 2). The values for suspended solids and BOD_5 are shown in Table 6.

The effect of the shock load was apparent in the first sample of effluent from the settling chamber (OUT 1) after 15 minutes of the application. The suspended solids in the samples collected after 15 minutes, 30 minutes and 45 minutes were 1441, 1741 and 1488 mg/l respectively. The BOD_5 values, showed an increase 75 to 90 minutes after the application of the load, the values being 89 and 72 mg/l respectively. The reactor returned to normal operation after about 2½ to 3 hours when the values of BOD_5 and suspended solids were 27.5 and 26.8 mg/l respectively.

In the samples of the effluent from the sand filter (OUT 2) there appeared to be no increase in BOD_5, although the suspended solids had increased from 13.6 to 36.8 mg/l between 15 and 30 minutes after the loading was applied. The value was reduced to 11.6 mg/l in the 60 minute sample, and continued to decrease until the system returned to normal in approximately 3 hours.

From these series of tests, it is concluded that a single organic and hydraulic shock load would upset the operation of the mechanical part of the system for two to three hours as indicated by the value of BOD_5 and suspended solids (OUT 1) when operating at 333 Imp. gallons per day sewage flow rate. The sand filter, however, absorbed the shock to a great extent.

Instead of only one shock load, a number of shocks were applied by dumping 45 Imp. gal. of sewage in 24 hours

according to the schedule described under loading of the system (Table 3). This procedure was intended to determine the change in performance of the system when the flow pattern is of a discontinuous type loading of the system.

The results of the analyses for BOD_5 and suspended solids of the 24 hour composite samples of the effluent from the settling chamber (OUT 1) are given in Table 7.

There was a wide variation in the values. OUT 1 the BOD_5 varied between 8 to 66 mg/l and Suspended Solids, 18 to 129 mg/l. The range of corresponding values from the filter bed (OUT 2) were less than 1 to 2 mg/l and 0.2 to 5.6 mg/l.

9.0 OPERATION AND MAINTENANCE

The air supply mechanisms, either for aeration of the waste or for the operation of the air lift pump, require more frequent attention than routine servicing every three months. This was mainly due to plugging of the outlets.

During the test period, there was no other mechanical failure.

No problems of odour or foaming were reported.

10.0 DISCUSSION

The Waltec Aquarobic System, during 12 months evaluation, operated at sewage flow rates of 212 and 333 Imp. gal. per day for approximately 4 months and 8 months respectively. The laboratory results of the two periods have been analyzed on a statistical basis, and the values for important parameters for 15%, 50% and 85% of the samples have been shown in Table 8 and Table 9. The corresponding ranges for maximum and minimum values are given in Table 1 and Table 2.

The period of operation between April 28, 1973 and May 24, 1973 was not included for evaluation of the system. The sewage feed pump for input to the system during this period was pumping more than 600 gallons per day (estimated by the ORF) which was much higher than the design capacity of the Aquarobic system. The system was not able to operate satisfactorily at this relatively higher rate of 600 gallons/day.

10.1 Period of Operation: September 5, 1972 to January 10, 1973.

Sewage Flow Rate: 212 Imp. gal/day.

The statistical analyses of the laboratory results (Table 8) indicate that the unit (OUT 1) at a sewage rate of 212 Imp. gal/day produced an effluent from the settling chamber with BOD_5 and suspended solids for 85% of the samples equal to or less than 25.6 and 41.2 mg/l respectively. The corresponding values for the effluent from the filter (OUT 2) were 5.2 and 9.5 mg/l. The volatile suspended solids were approximately 50% of the total suspended solids.

The phosphate reduction in the effluent from the unit (OUT 1) and the filter (OUT 2) in 85% of the samples was less than or equal to 23% and 21% respectively, showing a reduction of 44% or less in the whole process with a value of phosphorus (P) of 8.5 mg/l or less in the final effluent.

Although the nitrate content of raw sewage had a value less than or equal to 69.7 mg/l as N, on the basis of 85% of the samples, free ammonia and nitrate out of the unit (OUT 1) were still detectable, the values being less than or equal to 1.9 mg/l and 0.74 mg/l as N respectively. These two indicators of the oxidation process were further reduced (OUT 2) to 0.72 and 0.25 mg/l as N respectively.

The total and soluble organic carbon in the raw sewage for 85% of the samples was 127.8 and 65.5 mg/l or less; on treatment by the unit (OUT 1) these were reduced to 29.4 and 20.8 mg/l or less respectively. The corresponding values in the final effluent (OUT 2) were 18.5 and 16.3 mg/l.

10.2 Period of Operation: January 11, 1973 to September 4, 1973.

Sewage Flow Rate: 333 Imp. gal/day.

The sewage flow was increased from 212 to 333 Imp. gal/day beginning on January 11, 1973. During the initial three and a half months operation at this increased rate the values of BOD_5 and suspended solids from the unit (OUT 1) (Table 9A) for 85% of the samples were less than or equal to 62.2 and 126.9 mg/l respectively. The corresponding value for volatile suspended solids was 103.5 mg/l. The analyses of the effluents from May to September 1973 is shown in Table 9B.

With continued operation till September 4, 1973, however, these values, BOD_5 and suspended solids, (Table 10) for the entire period (January 11 to September 4, 1973) were reduced to 49.9 mg/l and 92.9 mg/l respectively. The volatile suspended solids on the same basis were equal to or less than 74.8 mg/l.

Similarly, the values for nitrogen compounds (OUT 1), free ammonia, Total Kjeldahl, nitrite and nitrate - expressed as N - changed from 3.0 mg/l, 21.2 mg/l, 0.43 mg/l and 30.3 mg/l to 1.5 mg/l, 9.5 mg/l, 0.3 mg/l and 32.77 mg/l respectively.

The presence of free ammonia and nitrate content in the effluent from the unit (OUT 1) during the initial four month period indicated that the nitrification process was not completed in the unit.

There was no significant change for OUT 1 in the total phosphorus content during the entire period of time at this sewage flow rate. The values for 50% and 85% of the samples were equal to or less than 7.9 mg/l and 9.5 mg/l as P respectively. The corresponding concentrations of phosphorus in raw sewage were 8.4 mg/l and 10.5 mg/l as P, the reduction in the unit being approximately 6%.

On the basis of the test results, the unit alone, without the filter, is considered equivalent to a Class II system according to the Plant Classifications Standard No. 40 of the National Sanitation Foundation, Ann Arbor, Michigan.

The treatment of the waste by the sand filter greatly improved the quality of the final effluent. The values of BOD

and suspended solids (OUT 2) for 85% of the samples for the initial 4 month period were less than or equal to 5.5 mg/l and 13.1 mg/l respectively. The corresponding volatile suspended solids were 5.0 mg/l or less. The corresponding values for BOD_5 suspended solids and volatile solids for the entire period of evaluation at this rate (333 Imp. gal/day) were 3.5 mg/l, 11.0 mg/l and 3.65 mg/l. The difference in these two sets of values is small and could not be considered significant. However, it brings out the fact that, although the effluent OUT 1, in the initial 4 month period (January 11, 1973 to April 29, 1973), had relatively much higher values for BOD and suspended solids than for the other period, values for the effluent OUT 2 from the sand filter were relatively the same.

The total phosphorus concentration for 85% of the samples of effluent discharged from the unit (OUT 1) and in the final effluent from the sand filter (OUT 2) were 9.5 and 7.4 mg/l or less as P respectively. The corresponding values for the total organic carbon concentrations were 35.2 and 16.1 mg/l respectively. The nitrogen compounds in the final effluent (OUT 2) i.e., free ammonia, Total Kjeldahl, nitrite and nitrate, for 85% of the samples were of concentrations equal to or less than 0.24, 1.3, 0.12 and 30.6 mg/l respectively. The corresponding nitrogen compounds concentrations in the effluent discharged from the unit (OUT 1) were 1.5, 9.5, 0.3 and 32.77 mg/l. In 50% of the samples there was no free ammonia in the effluent from the unit (OUT 1).

The series of "shock load" tests indicated that a single organic and hydraulic shock would upset operation of the unit for two to three hours as reflected in the values of BOD_5 and suspended solids in the effluent from the unit (OUT 1). Similarly, when the flow of sewage to the unit is of a pattern in the values of BOD_5 and suspended solids, indicating that the operation of the unit during interrupted loading could not be considered to be steady.

The sand filter, in all these cases, however, absorbed the shock to a great extent. However, it is too early to predict the useful life of the sand filter.

There was a considerable reduction in total and faecal coliforms through the sand filter. The counts in 50% of the sample OUT 1 were less than or equal to 660,000 in total coliform and 65,000 in faecal coliform per 100 ml. In the final effluent (OUT 2) corresponding values were1,470 and 360 per 100 ml. Considering 85% of the samples, the total and faecal coliform count for the unit (OUT 1) were equal to or less than 7,500,000 and 830,000 per 100 ml respectively. In the final effluent (OUT 2), the total and faecal coliform were less than or equal to 72,100 and 6,200 per 100 ml respectively.

11.0 CONCLUSIONS

Based on 12 months evaluation of continuous operation;-

1. The Aquarobic System, consisting of the mechanical unit (aeration and settling tanks) and the gravity sand filter, during the three test periods, produced final effluent with BOD_5 in 85% of the samples less than or equal to 5.2, 5.5 and 2.0 mg/l and suspended solids 9.5, 13.1 and 4.4 mg/l respectively. The corresponding values for the effluent from the mechanical unit before it discharged into the sand filter were 25.6, 62.2 and 41.0 mg/l for BOD_5 and 41.2, 126.9 and 63.0 mg/l for the suspended solids.
2. At the higher test flow rate (333 gal/day) an organic and hydraulic shock load, when applied to the system within 5 - 10 minutes, would upset normal operation of the mechanical unit for 2 - 3 hours. The BOD_5 and suspended solids at one stage were 89 mg/l and 1741 mg/l respectively. The sand filter absorbed the shock to a great extent. The values for suspended solids, in the filter bed effluent, increased to 36.8 mg/l after 30 minutes and then reduced to 11.6 mg/l after 60 minutes.
3. The useful life of the filter system, which plays a very significant role in the waste treatment process, could not be predicted. Discharging of suspended solids due to unexpected increased flow of waste for a prolonged period of time or repeated shock loads, could result in

clogging of the distribution pipes or the filter media in a relatively short period.

4. Additional treatment would be required for the removal of phosphorus and for disinfection of the effluent if disposal other than on-site is considered.
5. The air supply arrangement appeared to be the weakest link in the system requiring frequent attention and maintenance visits. Routine maintenance and assurance of prompt service in emergency is essential in order to keep the aerobic treatment system operating satisfactorily.
6. A high liquid level alarm in the aeration tank would be useful for indicating blockage in the airlift pump or in any other part of the system.
7. Monitoring of some of the field installations on a long term basis could provide necessary information regarding the life of the sand filters and a guide for a servicing schedule.

TABLE 1

Table of Maximum and Minimum Values in Experimental Data

Loading: 255 US gpd (212 Imp. gpd)

All values except coliform are in mg/l.
Coliform counts are in thousands/100 ml.

September 5, 1972 - January 10, 1973.

	IN (see sketch A)			OUT 1 (see sketch A)			OUT 2 (see Fig.2)		
	Range of Values		No. of Samples Tested	Range of Values		No. of Samples Tested	Range of Values		No. of Samples Tested
	Min.	Max.		Min.	Max.		Min.	Max.	
BOD	52.5	377.0	115	3.5	41.5	98	0.1	29.8	116
Suspended Solids	20.0	740.0	120	0.8	83.0	103	0.4	36.0	121
Volatile Suspended Solids	3.0	650.0	120	0.8	44.4	103	0.	9.6	102
Total Organic Carbon	35.0	207.0	119	12.0	58.0	100	9.0	34.0	120
Soluble Organic Carbon	8.0	102.0	118	10.0	47.0	101	7.0	31.0	119
Nitrogen as NH_3	-	-	-	0	22.2	15	0	3.28	18
Total Kjeldahl as Nitrogen	-	-	-	-	-	-	-	-	-
Nitrogen as Nitrite	-	-	-	0.135	0.927	12	0.009	0.59	13
Nitrogen as Nitrate	-	-	-	4.5	160.0	100	8.8	160.0	118
Phosphorus (P)	4.3	35.5	117	2.9	13.9	104	0	8.7	118
Total Coliform	-	-	-	1.7	480,000	15	0	360	15
Faecal Coliform	-	-	-	0.04	20,000	15	0	10	13

TABLE 2

Table of Maximum and Minimum Values in Experimental Data

Loading: 400 US gpd (333 I. gpd)

All values except coliform are in mg/l.
Coliform counts are in thousands/100 ml.

January 11, 1973 - September 4, 1973.

	IN			OUT 1			OUT 2		
	Range of Values		No. of Samples Tested	Range of Values		No. of Samples Tested	Range of Values		No. of Samples Tested
	Min.	Max.		Min.	Max.		Min.	Max.	
BOD	48	285	189	6	298	184	0.25	35	192
Suspended Solids	22	568	189	6	668	184	0.04	510	203
Volatile Suspended Solids	11	396	189	2	584	184	0.2	18	193
Total Organic Carbon	45	125	25	13	76	23	9	30	25
Soluble Organic Carbon	28	76	26	11	20	23	8	15	25
Nitrogen as NH_3	13	43	28	0	9.8	28	0	0.9	27
Total Kjeldahl as Nitrogen	10.65	58.7	27	0	61.3	27	0	1.7	27
Nitrogen as Nitrate	0.009	0.960	28	0.01	0.61	28	0.002	0.960	28
Phosphorus (P)	3.8	16.7	188	5.1	16.9	183	4.0	17.7	190
Total Coliform	90	500,000	26	0.3	20,000	25	0	119	26
Faecal Coliform	8	50,000	26	0	1.300	25	0	33	26

TABLE 3

Discontinuous Schedule of Loading (45 approx. Imp. gal. each time)

17/7/73	18/7	19/7	20/7	21/7
			0700	0700
1000 hours	0800	0800	0800	0800 (1/2 drum)
1100	0900	0900	0900	0900
1200		1200	1200	1200
1330	1330	1330	1330	1330
1700	1700	1700	1700	1700
1830	1830	1830	1830	1830

22/7	23/7	24/7	25/7	26/7
0700 hours	0700 digging on site	0700	0700	0700
0800	0800	0800 (2/3)	0800	0800
0900	0900	0900	0900 (tempest)	0900
1200	1200	1200	1200	1200
1330	1330	1330	1330	1330
1700	1700	1645	1645	1700
1830	1830 (1/2)	1845	1845	1845
1930	1930	1945	1930	1945

14/8/73	15/8	16/8	17/8	18/8
- hours	0700	0700	0700	0700
-	0800	0800	0800	0800
-	0900	0900	0900	0900
-	1200	1200	1200	-
-	1330	1330	1330	-
1700	1700	1700	1700	-
1830	1830	1830	1830	-
1930	1930	1930	1930	-

TABLE 4

BOD & Suspended Solids After Shock Load (14th December, 1972)

	Hours	S.S. (mg/l)	BOD_5 (mg/l)
	0	30.8	22
	0.5	39.6	34
	1.0	37.2	23
	1.5	28.0	15
Noon feeding (	2.0	21.6	17
(	2.5	18.4	16
(	3.0	20.4	15
(	3.5	28.0	20
	4.0	31.2	22
	4.5	28.0	19
	5.0	18.8	15
After AM feeding	23	42.8	22
After noon feeding	28	39.2	22

TABLE 5

BOD & Suspended Solids After Shock Load (9th January,1973)

	Elapsed Hours	S.S. (mg/1)	BOD_5(mg/1)
January 9,1973	0	46.0	18.6
	0.5	87.0	36.2
	1.0	495.0	82.5
	1.5	128.0	62.5
	2.0	29.0	20.4
	2.5	16.0	15.8
Noon feeding	(3.0	13.2	12.8
(0.5 U.S. gpm)	(3.5	13.6	12.0
	4.0	20.0	10.8
	4.5	22.0	14.7
	5.0	31.6	22.4
Immediately following A.M. feeding (1 U.S. gpm)	24.25	35.2	21.0
Immediately following noon feeding (0.5 U.S. gpm)	28	32.8	17.4

TABLE 6

BOD & Suspended Solids After Shock Load (February 20, 1973)

Elapsed Hours	OUT 1 S.S. (mg/l)	OUT 1 BOD_5 (mg/l)	OUT 2 S.S. (mg/l)	OUT 2 BOD_5 (mg/l)
0	56.8	29.5	10.0	4.8
0.25	1441.0	35.5	13.6	4.8
0.50	1741.0	35.5	36.8	4.6
0.75	1488.0	35.8	19.6	4.75
1.00	832.0	27.0	11.6	4.75
1.25	196.0	89.0	8.8	5.25
1.50	83.0	72.0	8.4	4.50
2.00	45.0	47.0	9.6	4.20
2.50	32.0	43.5	4.8	3.50
3.00	26.8	27.5	6.4	2.80
3.50	24.8	25.0	6.8	3.00
4.00	26.4	29.0	6.0	3.90
4.50	30.0	34.5	3.6	3.00
5.00	38.0	41.0	2.4	3.00
24.00	76.4	54.5	13.2	4.10

TABLE 7

BOD & Suspended Solids With Discontinuous Type of Loading.

Date	BOD (mg/1)		Suspended Solids (mg/1)	
	OUT I	OUT 2	OUT I	OUT 2
17.7.73	55	2	74	2.4
18.7.73	19	1	18	1.6
19.7.73	8	2	29	1.6
20.7.73	23	1	42	0.4
21.7.73	8	< 1	33	0.2
22.7.73	11	1	21	0.8
23.7.73	34	< 1	118	5.6
24.7.73	66	1	67	4.2
25.7.73	7.5	< 1	87	3.2
26.7.73	27	< 1	129	3.8

TABLE 8

Statistical Analysis of Results from
September 5, 1972 to January 10, 1973

Loading: 255 US gpd (212 I.gpd)

	IN			OUT 1			OUT 2		
	% of time equal to or less than								
	15%	50%	85%	15%	50%	85%	15%	50%	85%
BOD	124.2	174.7	245.8	10.2	16.1	25.6	0.6	1.8	5.2
Suspended Solids	50.9	101.2	201.2	9.2	19.5	41.2	0.9	3.0	9.5
Volatile Suspended Solids	36.8	79.3	171.0	6.2	13.9	30.9	*0.6	1.6	5.0
Nitrogen as Ammonia	-	-	-	*0.04	0.27	1.9	*0.021	0.12	0.72
Nitrogen as Nitrite	-	-	-	*0.23	0.41	0.74	*0.014	0.06	0.25
Nitrogen as Nitrate	-	-	-	19.7	38.7	76.3	18.1	35.5	69.7
Total Organic Carbon	60.5	88.0	127.8	16.1	21.8	29.4	10.6	14.0	18.5
Soluble Organic Carbon	31.8	45.6	65.6	11.7	15.6	20.8	9.6	12.5	16.3
Phosphorus (P)	7.8	10.2	13.3	6.3	8.2	10.8	3.8	5.7	8.5
Total Coliform	-	-	-	*110	1,100	11,100	* 0.022	1.45	93.0
Faecal Coliform	-	-	-	* 0.38	10.0	250.0	* 0.012	0.13	1.4

NB. All values, except coliform counts, are in mg/l
Coliform counts are in thousands/100 ml.

* values obtained from graphs.

TABLE 9A

Statistical Analysis of Results from
January 11, 1973 to April 28, 1973.
Loading: 333 Imp. Gallons/d.

	IN			OUT 1			OUT 2		
	% of time equal to or less than								
	15%	50%	85%	15%	50%	85%	15%	50%	85%
BOD	102.5	145.3	206.1	19.2	34.5	62.2	1.0	2.3	5.5
Suspended Solids	56.5	92.2	150.3	24.1	55.3	126.9	1.5	4.4	13.1
Volatile Suspended Solids	37.8	68.3	123.3	15.8	40.0	103.5	*0.3	1.2	5.0
Total Organic Carbon	64.8	84.3	109.8	16.1	23.8	35.2	9.6	12.6	16.6
Soluble Organic Carbon	34.3	45.4	60.0	12.3	14.5	17.0	9.0	10.8	13.0
Nitrogen as Ammonia	16.0	23.3	33.9	* 0.1	0.31	3.0	* 0.1	* 0.1	0.44
Total Kjeldahl as Nitrogen	16.4	27.1	44.8	*1.4	5.4	21.2	* 0.48	0.78	1.3
Nitrogen as Nitrite	0.026	0.1	0.38	*0.029	0.11	0.43	* 0.012	0.061	0.31
Nitrogen as Nitrate	0.7	1.1	1.8	20.3	24.9	30.5	17.5	22.5	28.9
Phosphorus (P)	7.0	8.9	11.7	6.6	8.5	10.9	4.6	5.8	7.6
Total Coliform	*22,000	95,000	420,000	*70	940	13,000	* 0.025	1.1	46.0
Fecal Coliform	* 4,200	11,200	30,000	*2.0	27.0	370.0	* 0	0.13	4.7

NB, All values, except coliform counts, are in mg/l
Coliform counts are in thousands/100 ml.

* values obtained by graphical method.

TABLE 9B

Statistical Analysis of Results

May 25/73 to Sept. 4/73

loading: 400 US gpd (333 I. gpd)

	IN			OUT 1			OUT 2		
	% of time equal to or less than								
	15%	50%	85%	15%	50%	85%	15%	50%	85%
BOD	115	142	180	9.5	20.0	41.0	1.0	1.2	2.0
Suspended Solids	46	94	190	15.0	31.0	63.0	0.37	1.28	4.4
Volatile Suspended Solids	41	76	140	11.9	24.1	48.5	0.22	0.81	3.0
Total Organic Carbon	no analysis								
Soluble Organic Carbon	no analysis								
Nitrogen as Ammonia	20.0	25.6	32.7	0	0	0.4	0	0	0
Total Kjeldahl as Nitrogen	35.3	42.9	52.0	2.1	4.1	7.8	0.7	0.9	1.1
Nitrogen as Nitrite	0.011	0.026	0.059	0.026	0.074	0.206	0.002	0.005	0.0
Nitrogen as Nitrate	1.0	1.5	2.2	23.7	28.5	34.3	22.5	26.7	31.8
Phosphorus (P)	6.7	7.9	9.3	6.7	7.5	8.2	5.8	6.4	7.0
Total Coliform	100,000	172,000	290,000	250	960	3,700	0.26	3.9	60.0
Fecal Coliform	8,200	16,000	32,000	28	105	570	0.05	0.81	13.7

N.B. All values except Coliform are in mg/l. Total and Fecal coliform counts are in thousands/100 ml.

TABLE 10

Statistical Analysis of Results from
January 11, 1973 to September 4, 1973.

Loading: 333 Imp. Gallons/d.

	IN			OUT 1			OUT 2		
	% of time equal to or less than								
	15%	50%	85%	15%	50%	85%	15%	50%	85%
BOD	105.8	142.6	192.2	12.1	24.5	49.9	0.80	1.7	3.5
Suspended Solids	50.5	93.2	171.8	18.5	41.5	92.9	0.64	2.6	11.0
Volatile Suspended Solids	37.7	73.1	141.8	12.3	30.3	74.8	0.25	0.96	3.65
Total Organic Carbon	64.8	84.3	109.8	16.1	23.8	35.2	9.6	12.6	16.6
Soluble Organic Carbon	34.3	45.4	60.0	12.3	14.5	17.0	9.0	10.8	13.0
Nitrogen as Ammonia	17.983	24.458	33.264	0	0	1.510	0	0	0.243
Total Kjeldahl as Nitrogen	21.5	33.7	52.8	2.1	4.4	9.5	0.58	0.87	1.30
Nitrogen as Nitrite	0.015	0.053	0.192	0.034	0.098	0.299	0.003	0.018	0.124
Nitrogen as Nitrate	0.80	1.28	2.06	21.74	26.69	32.77	19.47	24.43	30.66
Phosph orus (P)	6.7	8.4	10.5	6.5	7.9	9.5	5.1	6.1	7.4
Total Coliform *	21,800	100,400	462,000	58.0	660.0	7500.0	0.030	1.470	72.14
Fecal Coliform *	1,760	8,900	45,000	5.0	65.0	830.0	0.021	0.36	6.20

NB. All values, except coliform counts, are in mg/l
Coliform counts are in thousands/100 ml.

* values obtained by graphical method.

FLOW DIAGRAM FOR AQUAROBIC SYSTEM (WALTEC INDUSTRIES)

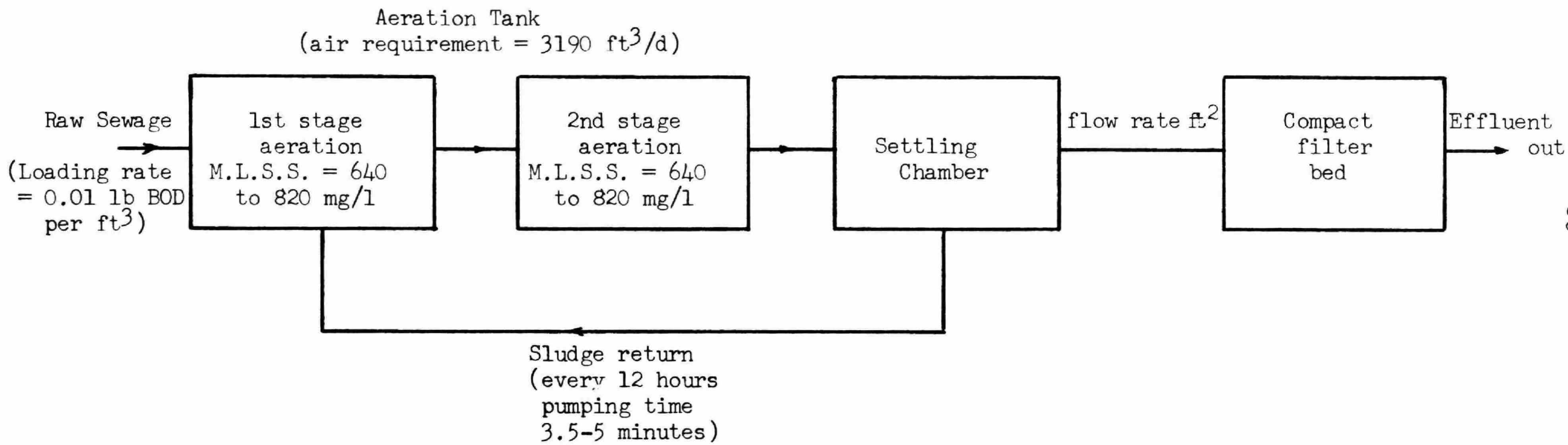
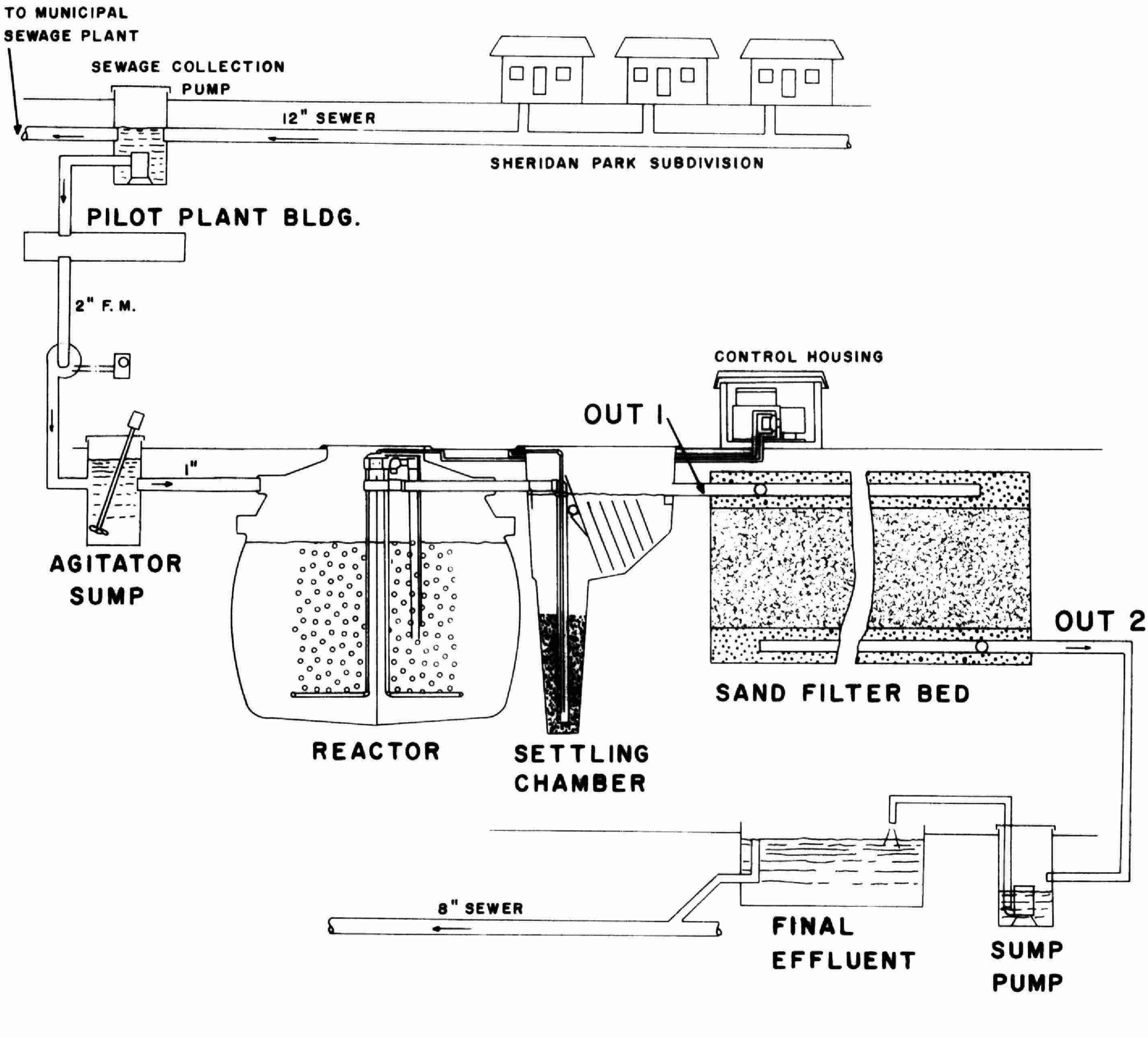
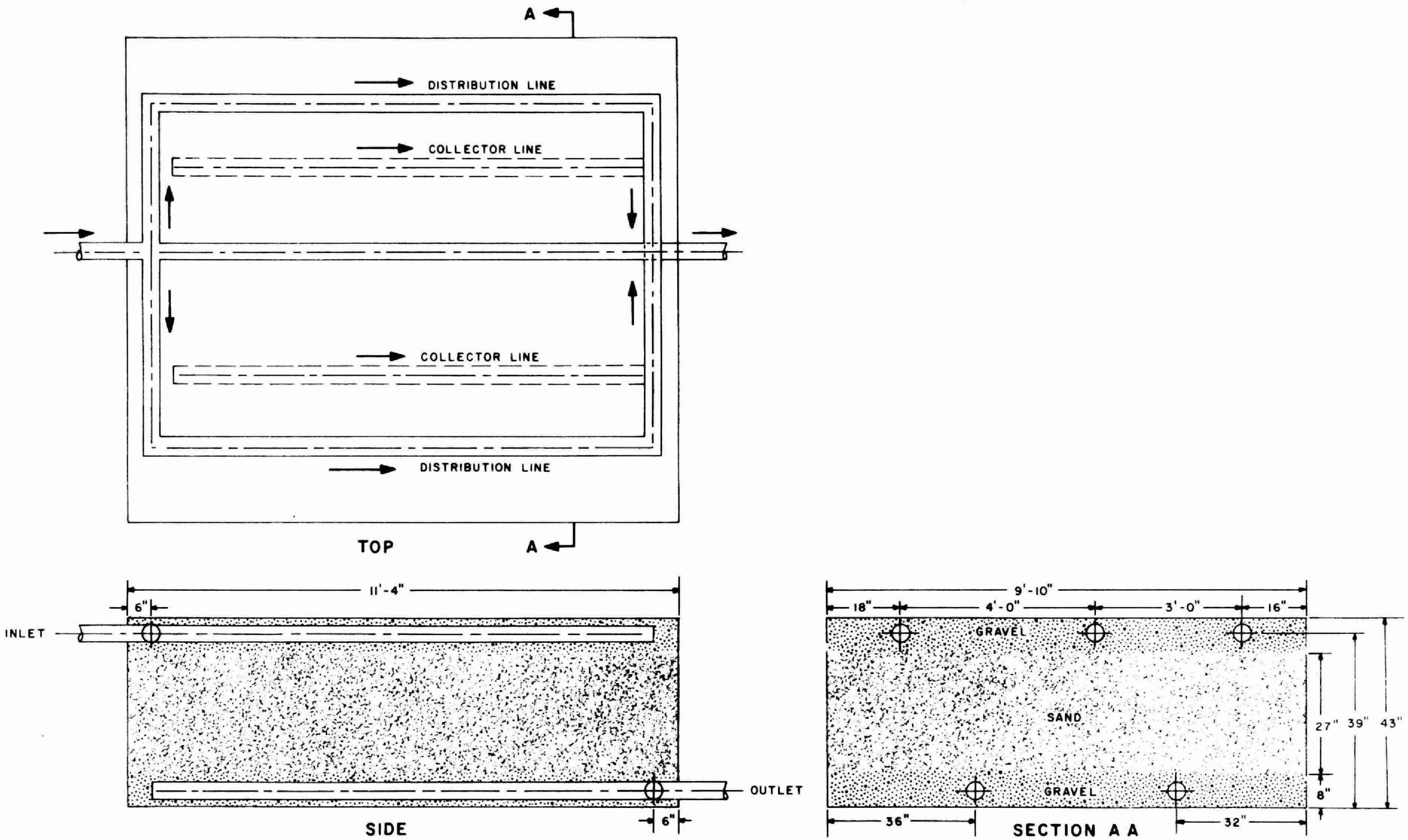


Figure 1



SKETCH COURTESY
WALTEC INDUSTRIES LIMITED

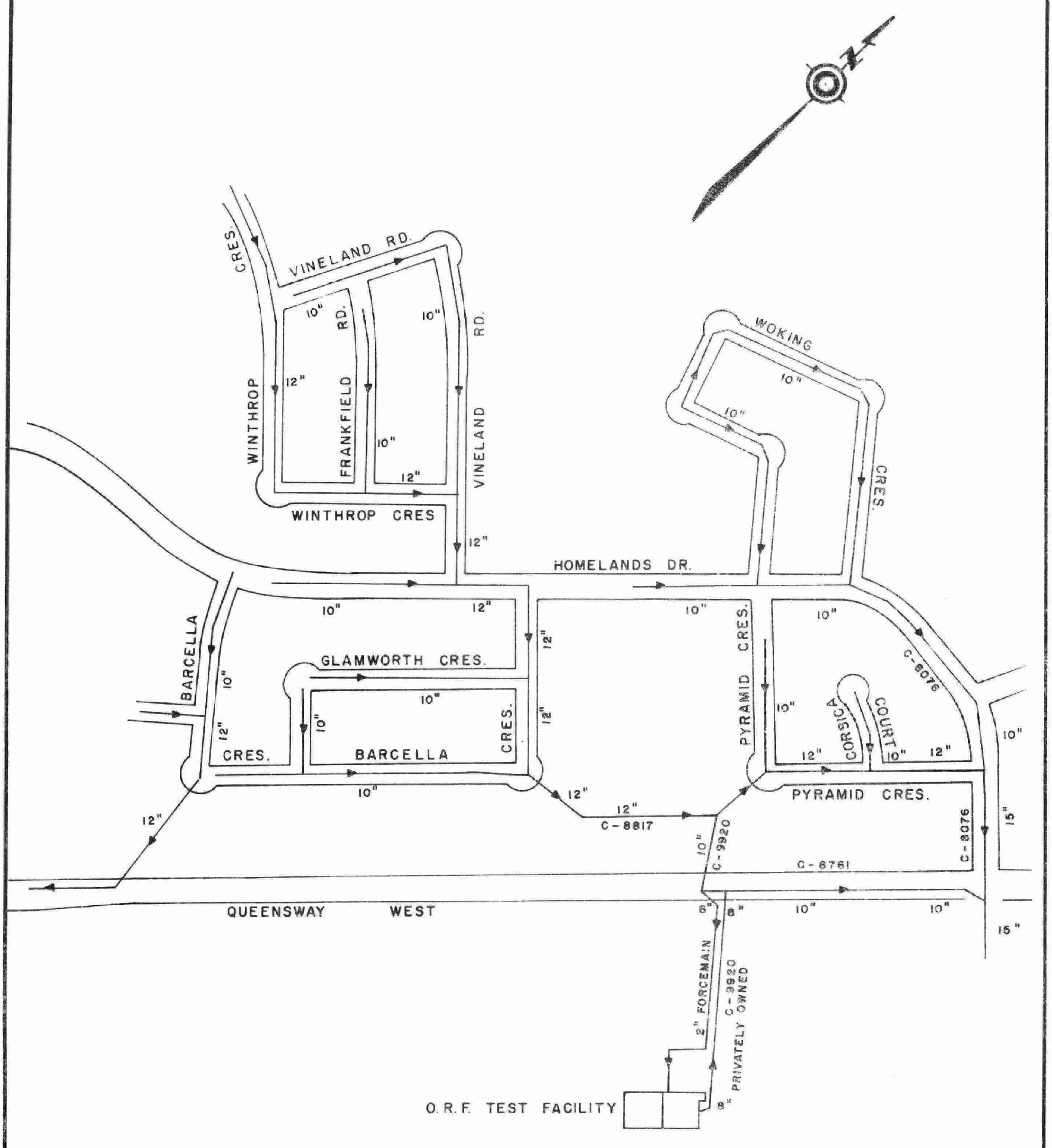
ENVIRONMENT ONTARIO	
Fig. 2 SHERIDAN PARK TEST INSTALLATION	
SCALE: NOT TO SCALE	
DRAWN BY: R.S.	DATE: FEB. 1974
CHECKED BY:	DRAWING Nº: 74-16



ENVIRONMENT ONTARIO

Fig. 3 SAND FILTER BED

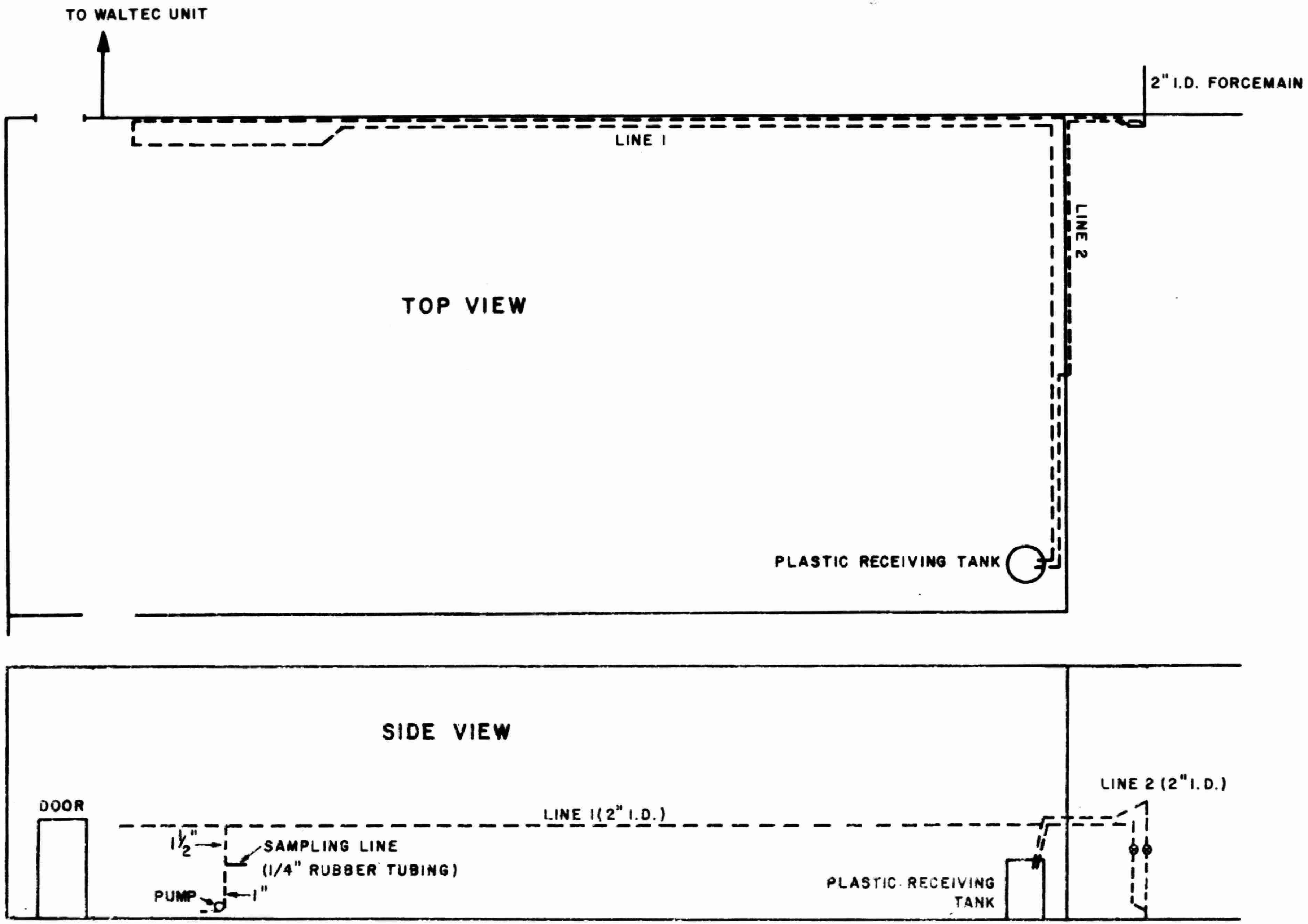
SCALE: NOT TO SCALE
DRAWN BY: R.S.
DATE: JANUARY 1974
CHECKED BY:
DRAWING Nº. 74-8



ENVIRONMENT ONTARIO

FIG. 4 – SHERIDAN PARK SEWER SYSTEM

SCALE: NOT TO SCALE	
DRAWN BY: R.S.	DATE: MAY 1974
CHECKED BY:	DRAWING Nº 5023



SCHEMATIC DIAGRAM SHOWING SEWAGE LINES AT THE O.R.F.

NOT TO SCALE